MODELLING HOUSEHOLD MORTGAGE DEBT: THE CASE OF THE CZECH REPUBLIC*

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Abstract

This paper deals with Czech household mortgage debt and its determinants in the period 1Q2005–2Q2021. Our analysis focuses on the variables determining the level of mortgage debt from both short- and long-term perspectives. Our contribution is two-fold. Firstly, we examine the relationship between the selected variables within a cross-correlation analysis. The results confirm the positive dependency of household mortgage debt and real GDP, real gross average income and the level of house prices. By contrast, a negative relationship was identified for real interest rates, the unemployment rate and the inflation rate. Secondly, we explore the ARDL and EC models and identify one cointegration relationship. Our results confirm that house prices and real wages are determinants of household mortgage debt in the long-term perspective. However, a wider range of variables plays a role in the short run, including house prices, real gross average income, inflation and long-term interest rates. Moreover, our model indicates the insignificance of unemployment in both the short and long run.

Keywords: Mortgage debt, household debt, cointegration, ARDL model
JEL Classification: C01, C22, G51

1. Introduction

During the last decade, the mortgage market has displayed relatively strong growth in the Czech Republic and many other European countries. The cumulative change in Czech households' mortgage debt reached 122% between 2010 and 2020 according to the Czech National Bank's (CNB) statistics. Mandel and Teplý (2018) provide empirical evidence

* The article is processed as an output of research projects registered by the Prague University of Economics and Business (Project IGS 47/2022 Nové trendy a inovace na finančních a kapitálových trzích, No. IG102032) and the Czech Science Foundation (Project No. GA 20-00178S).

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of the trends in household debt development. A low level of interest rates, the easing of credit standards and an upward trend in house prices have been deemed to be the main drivers of rapid growth. The CNB (2018) also emphasized that the enormous increase in credit for house purchases was faster than the average income growth.

In response, the CNB has activated borrower-based macroprudential policy measures in order to reduce the increase in systemic risk associated with exposures secured by real estate (Fiala and Teplý, 2021; CNB, 2020a).[1] The activation of those measures has been explained in connection with the development of macroeconomic and financial variables, which have been considered to be the main drivers of the growing demand for mortgages.

A large part of the research has focused on the role of credit in the economy and its impact on the real economy and the financial sector due to the negative consequences of the global financial crisis (GFC). Somewhat less attention has been paid to demand for credit, *i.e.*, factors determining the level of indebtedness.

This article focuses on the determinants of mortgage debt in the Czech Republic. The main objective is to provide empirical evidence based on the econometric analysis of selected variables (of a macroeconomic and financial nature) which determine the level of mortgage debt.

The remainder of the paper is organized as follows: The second chapter provides a literature review of the relevant research outputs. The following part (3.1) presents the datasets examined and the methodology used. In section 3.2, we present the results of a cross-correlation analysis. A further section (3.3) concludes the econometric analysis based on the Autoregressive Distributed Lag (ARDL) model and the error correction (EC) model, while the fourth chapter is dedicated to the results and a discussion. Finally, we discuss our main conclusions.

2. Literature Review

Household indebtedness has already been analysed from different angles. With reference to the GFC, the research has focused on the impact of debt on economic growth (see Mian and Sufi, 2010; Lombardi *et al.*, 2017; Alter *et al.*, 2018). Furthermore, a certain part of the research has examined the risk associated with household indebtedness and the occurrence of financial crises (for example Jorda *et al.*, 2015 and 2016; Chmelař, 2013). Less research activity has been focused on the factors determining households' demand for credit, especially mortgage credit.

1 These instruments cover the loan-to-value ratio, debt-to-income ratio and debt service-to-income ratio. The instruments have been implemented in line with the ESRB (2013) recommendation and the CNB's macroprudential policy strategy (CNB, 2020b). For more details about borrower-based measures, see Hejlová et al. (2021).

The key factors influencing the development of mortgage credit have been analysed by Kearl *et al.* (1974), who present the level of interest rates as the key demand factor. Interest rate increases are considered to affect demand negatively through the expectations channel. In line with this, those borrowers expecting a decline in interest rates lower their demand for loans in the short run until the rates slump. Moreover, the negative effect of interest rate growth is explained by an increase in debt service, causing a decline in demand.

Stockhammer and Wildauer (2018) present an empirical analysis of household debt determinants in 13 OECD countries. Their results confirm the prices of residential real estate as the key variable determining the level of household indebtedness. House prices caused between 25 and 39% of the total of 54% growth in debt. The key role of house prices is in line with other research, for example Borio (2012) or Bezemer *et al.* (2017). The research also proved that the level of interest rates is a statistically significant variable, due to the fact that the contribution to the total household debt increase ranged between 2 and 14% depending on the selected estimator.

Basten and Koch (2016) discuss the importance of house prices as a debt determinant in Switzerland. The authors conduct a causal effect analysis and emphasize the demand channel, *i.e.,* higher house prices fuel the mortgage supply. Their results, however, confirm that the high level of house prices (*i.e.,* high value of collateral) does not lead to a greater effort by the banking sector to ease credit standards when granting loans or lowering interest rates.

Everaert *et al.* (2015) present the key role of house prices as well. The growing demand for loans is presented as being in line with strong economic growth and a low level of interest rates. Nevertheless, their model of demand is based on the total volume of granted loans, which does not reflect the differences between the sectors drawing the loans. Very similar findings have been made by Philbrick and Gustafsson (2010) as part of a cointegration analysis in the case of Australia. From a long-term perspective, the debt is affected positively by house prices and negatively by interest rates. The authors explain two ways in which interest rates can have an impact. The first one deals with the income effect, which explains the increase in income associated with higher returns from assets held when interest rates go up. The second one describes the role of the substitution effect, which leads to reduced consumption in the case of higher interest rates which scale up debt service.

Calza *et al.* (2001) prove a negative relationship between interest rates and the debt of the private sector in the Eurozone. Their results confirm the negative contribution of the short-term (3M interbank rate) and long-term (10Y government bond yields) interest rate. They also pointed out the positive influence of real GDP due to higher investment

returns during economic expansion, which leads to credit growth financing the investments. The authors also, by contrast, present the view that companies and households are more likely to use their income in the expansion phase of the economic cycle; they replace the income by drawing loans during a recession, which leads to higher demand for credit, *i.e.,* countercyclical development.

Jacobsen *et al.* (2004) also confirm the key role of house prices in the case of Norway. From a long-term perspective, the authors point out a positive relationship between household debt and house prices, which is caused by the wealth effect. The higher demand for credit is caused by increasing collateral prices and a low level of interest rates. Very similar findings are presented by the OECD (2017) and André (2016) in the case of house prices. Jacobsen *et al.* (2004) also highlight the positive effect of income growth, which increases the ability to service debt. Apart from that, they prove a negative effect of unemployment associated with reduced incomes and uncertainty about their future development.

Davenport (2003) analyses the factors influencing the availability of owner-occupied housing in the USA. The model used confirms the negative effect of income per capita, which can serve as a proxy for demand for loans taken out to finance housing needs. By contrast, an increasing unemployment rate signals the reduced affordability of housing. In the context of US household debt, Turinetti and Zhuang (2011) provide empirical evidence of the negative contribution of the unemployment rate and interest rate, whereas house prices contribute positively.

Samad *et al.* (2020) examine the household debt development in 19 emerging economies within a correlation analysis and panel regression analysis. The results of the correlation analysis prove the negative impact of unemployment and interest rates, whereas a GDP per capita increase leads to a growth in debt. On the other hand, their panel regression shows different results in the case of interest rates. The positive relationship is explained in connection with a strong demand for loans and also with consumers' low sensitivity to interest rate increases. Mian and Sufi (2008) emphasize that this causality can be explained by the varying creditworthiness of different borrowers and thus different risk premiums for creditworthy applicants and riskier borrowers.

Nieto (2007) presents an analysis of demand factors in both the short run and the long run based on Johansen's methodology in the case of Spain. The study proves a long-term positive relationship between household debt and real consumption and wealth, and a negative connection to unemployment and the costs of credit. From the short-term perspective, the demand for household debt is influenced by changes in unemployment and long-term interest rates.

Following on from this literature review, the objective of this paper is to analyse how house prices, real GDP, real interest rates, consumer prices (inflation rate), unemployment

and the level of average income influence the level of Czech household mortgage debt, *i.e.,* how the demand for mortgage debt is affected by the above-mentioned variables. The research is based on the following two hypotheses:

Hypothesis 1:
We assume a positive relationship between household mortgage debt and the level of house prices, real GDP, the inflation rate and the level of gross average income.

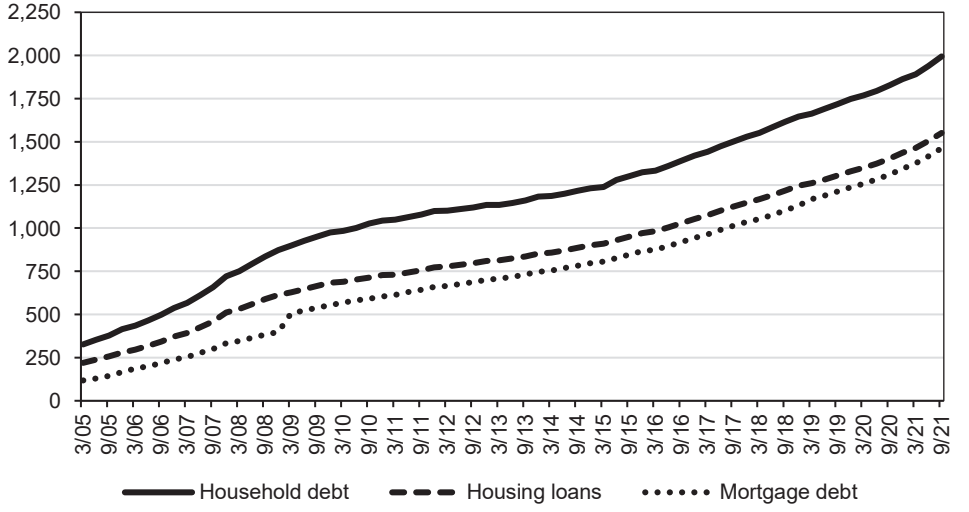
Hypothesis 2:
We assume a negative effect of real interest rates and the unemployment rate on household mortgage debt.

3. Empirical Analysis

3.1 Data and methodology

As Figure 1 shows, the majority of Czech household debt is made up of mortgage debt (outstanding mortgage loans granted to households). In our analysis, we aim to observe the determinants of mortgage debt for two reasons. The first one is to capture the variables determining the major part of the household debt, and the second one is to analyse only secured debt due to the potentially different household behaviour when an unsecured loan is drawn.

Figure 1: Household debt structure (CZK million)



Source: Authors' elaboration based on Czech National Bank (2022)

We use data on real mortgage loans granted to the household sector, real long-term interest rates, real GDP, real wages, consumer prices, unemployment and house prices. Real mortgage loans are measured as the logged quarterly averages of the outstanding amounts at the end of the month granted to the household sector (seasonally adjusted). Real long-term interest rates are given by the quarterly averages of 10Y government bond yields. Real GDP and real wages are counted as the logs of their nominal values on a quarterly basis (seasonally adjusted). The unemployment rate is given by the logged quarterly averages from the monthly data. House prices correspond to the logs of the quarterly index of the offer prices of flats published by the Czech Statistical Office. Consumer prices are measured by the harmonised index of consumer prices published by the Czech Statistical Office. In the case of real variables, their nominal values are deflated by a GDP deflator. The information about the dataset is summarized in Appendix 1 and the developments of selected variables are shown in Figures 2–4 in Appendix 1.

In the first step, we run a cross-correlation analysis in order to test the linear relationship between the underlying variables. Furthermore, we test the stationarity (unit roots) of the time series by using the augmented Dickey-Fuller test (ADF) and the Phillips-Peron test (PP). Following these results, we build the ARDL model and specify the long-run and short-run relationships of the tested variables via a transformation into an EC model. When specifying the long-run relation, we use the Engle-Granger test and a bounds test.

3.2 Cross-correlation analysis

Table 1 concludes the results of the cross-correlation analysis, showing the linear dependency between the analysed variables. The outcomes are significant at a 1% confidence level (rejection of the null hypothesis expecting no linear relationship).

Table 1: Cross-correlation analysis

	LOANS	*HP*	*rGDP*	*RIR*	*UNEM*	*rWAGES*	*HICP*
LOANS	1.0	–	–	–	–	–	–
HP	0.92	1.0	–	–	–	–	–
rGDP	0.96	0.97	1.0	–	–	–	–
RIR	−0.76	−0.56	−0.70	1.0	–	–	–
UNEM	−0.76	−0.88	−0.88	0.56	1.0	–	–
rWAGES	0.98	0.96	0.98	−0.68	−0.81	1.0	–
HICP	−0.08	0.15	0.04	0.31	−0.27	0.02	1.0

Source: Authors' computation based on EViews

The correlation coefficient shows a negative relationship between mortgage debt and real interest rates. From the perspective of the strength of the relationship, a relatively high degree of negative linear dependency was confirmed. This implies a reduction in the demand for loans due to their higher price, which is fuelled by growing interest rates and/or risk premiums. A negative relationship was also proved in the case of the unemployment rate. A higher level of unemployment indicates a decrease in household income, leading to a lower probability of debt repayment as a result of reduced household incomes. In this context, the credit institutions are more prudent when granting loans. The affordability of credit decreases. These results are in line with the first hypothesis.

However, a negative relationship was proved in the case of consumer prices too. This outcome is not in line with our hypothesis, which is based on the following assumption: In an environment of higher inflation, a rational consumer is more willing to take out a loan due to the decrease in the real value of the debt. Moreover, the rise in inflation can be caused by nominal wage growth as the key parameter for households' decisions on an increase in their indebtedness. On the other hand, the inflation rise is usually followed by an increase in central banks' monetary policy interest rates, causing an increase in loan interest rates. The overall effect of inflation on household (mortgage) debt therefore depends on the approach of the central bank, which is expected to tighten monetary policy, and on the impact on clients' interest rates, which affects the decisions of consumers.

By contrast, a positive relationship was identified for the rest of the tested variables, *i.e.,* house prices, real GDP and real wages. These findings correspond to those mentioned in the literature review and are in line with our hypothesis.

3.3 Cointegration analysis

The cointegration analysis is based on a test of the following equation, which also shows the assumed relationship that we mentioned in our hypotheses.

$$\underset{}{LOANS} = f\left(\underset{+}{HP}, \underset{+}{rGDP}, \underset{+}{rWAGES}, \underset{-}{RIR}, \underset{-}{UNEM}, \underset{+}{HICP}\right). \tag{1}$$

Firstly, we test the stationarity of the time series via unit root tests (ADF and PP tests). The PP test, however, indicated the stationarity of *HICP* at a 10% confidence level. We treat this variable as I(1) regarding the statistical significance of the first difference at a 1% confidence level. The results are summarized in Table 2 and suggest that the time series are integrated of order one (I(1)).

Table 2: Results of unit root test

		HP	*LOANS*	*rGDP*	*rWAGES*	*RIR*	*UNEM*	*HICP*
Level	**ADF *p*-value (*t*-statistic)**	0.94 (−0.13)	0.99 (0.74)	0.86 (0.96)	0.99 (0.93)	0.77 (−0.95)	0.53 (−1.49)	0.19 (−2.27)
	PP *p*-value (*t*-statistic)	0.99 (0.57)	0.99 (0.63)	0.86 (−1.11)	0.99 (−0.31)	0.74 (−1.02)	0.60 (−1.35)	0.07* (−2.77)
1st diff	**ADF *p*-value (*t*-statistic)**	0.04** (−2.97)	0.00*** (−7.51)	0.00*** (−2.19)	0.69 (−1.14)	0.00*** (−6.84)	0.01** (−3.68)	0.00*** (−5.99)
	PP *p*-value (*t*-statistic)	0.04** (−3.04)	0.00*** (−0.57)	0.00*** (−20.61)	0.00*** (−21.79)	0.00*** (−6.84)	0.00*** (−3.79)	0.00*** (−5.42)
Order of integration		I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

Note: Null hypothesis: existence of unit root. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels respectively. In the case of real wages, we confirm stationarity of the first difference with the Kwiatkowski-Phillips-Schmidt-Shin test.

Source: Authors' computation based on EViews

In line with the objective of this article, we explore the ARDL model, which is expressed as Equation 2. Furthermore, this model is transformed into a long-run (cointegration) relationship (Equation 3) and a short-run relationship (Equation 4).

$$\begin{aligned}\Delta\ln\left(LOANS\right)_t = {} & \alpha_0 + \sum_{i=1}^{n}\alpha_{1,i}\Delta\ln\left(LOANS\right)_{t-i} + \sum_{i=1}^{n}\alpha_{2,i}\Delta\ln\left(HP\right)_{t-i} + \\ & + \sum_{i=1}^{n}\alpha_{3,i}\Delta HICP_{t-i} + \sum_{i=1}^{n}\alpha_{4,i}\Delta\ln\left(rGDP\right)_{t-i} + \\ & + \sum_{i=1}^{n}\alpha_{5,i}\Delta\ln\left(rWAGES\right)_{t-i} + \sum_{i=1}^{n}\alpha_{6,i}\Delta RIR_{t-i} + \\ & + \sum_{i=1}^{n}\alpha_{7,i}\Delta\ln\left(UNEM\right)_{t-i} + \Psi_1\ln\left(LOANS\right)_{t-1} + \Psi_2\ln\left(HP\right)_{t-1} + \\ & + \Psi_3 HICP_{t-1} + \Psi_4\ln\left(rGDP\right)_{t-1} + \Psi_5\ln\left(rWAGES\right)_{t-1} + \\ & + \Psi_6\left(RIR\right)_{t-1} + \Psi_7\ln\left(UNEM\right)_{t-1} + \varepsilon_t,\end{aligned} \tag{2}$$

where α and Ψ refer to the short-run and long-run parameters; ε is assumed to be IID.

$$\ln\left(LOANS\right)_t = \gamma_1 + \sum_{i=1}^{n}\gamma_{1,i}\Delta\ln\left(LOANS\right)_{t-i} + \sum_{i=1}^{n}\gamma_{12,i}\Delta\ln\left(HP\right)_{t-i} +$$
$$+ \sum_{i=1}^{n}\gamma_{13,i}\Delta HICP_{t-i} + \sum_{i=1}^{n}\gamma_{14,i}\Delta\ln\left(rGDP\right)_{t-i} + \sum_{i=1}^{n}\gamma_{15,i}\Delta\ln\left(rWAGES\right)_{t-i} + \quad (3)$$
$$+ \sum_{i=1}^{n}\gamma_{16,i}\Delta RIR_{t-i} + \sum_{i=1}^{n}\gamma_{17,i}\Delta\ln\left(UNEM\right)_{t-i} + \varepsilon_{2t},$$

$$\Delta\ln\left(LOANS\right)_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1,i}\Delta\ln\left(LOANS\right)_{t-i} + \sum_{i=1}^{n}\alpha_{2,i}\Delta\ln\left(HP\right)_{t-i} +$$
$$+ \sum_{i=1}^{n}\alpha_{3,i}\Delta HICP_{t-i} + \sum_{i=1}^{n}\alpha_{4,i}\Delta\ln\left(rGDP\right)_{t-i} +$$
$$+ \sum_{i=1}^{n}\alpha_{5,i}\Delta\ln\left(rWAGES\right)_{t-i} + \sum_{i=1}^{n}\alpha_{6,i}\Delta RIR_{t-i} + \quad (4)$$
$$+ \sum_{i=1}^{n}\alpha_{7,i}\Delta\ln\left(UNEM\right)_{t-i} + \phi ECT_{t-1} + \varepsilon_{3t},$$

where Φ refers to the coefficient of the error correction term (ECT_{t-1}). The error correction term can be written as follows (Equation 5):

$$ECT_{t-1} = \varepsilon_{2t} = \ln\left(LOANS\right)_t - \gamma_1 + \sum_{i=1}^{n}\gamma_{1,i}\Delta\ln\left(LOANS\right)_{t-i} +$$
$$+ \sum_{i=1}^{n}\gamma_{12,i}\Delta\ln\left(HP\right)_{t-i} + \sum_{i=1}^{n}\gamma_{13,i}\Delta HICP_{t-i} + \sum_{i=1}^{n}\gamma_{14,i}\Delta\ln\left(rGDP\right)_{t-i} + \quad (5)$$
$$+ \sum_{i=1}^{n}\gamma_{15,i}\Delta\ln\left(rWAGES\right)_{t-i} + \sum_{i=1}^{n}\gamma_{16,i}\Delta RIR_{t-i} + \sum_{i=1}^{n}\gamma_{17,i}\Delta\ln\left(UNEM\right)_{t-i}.$$

In this paper, the econometric model formally written by Equations 3–5 refers to Model 1. In order to confirm the presence of a cointegration relationship (long-run equilibrium), we run the cointegration bounds test. The null hypothesis of this test is stated as follows: $\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4 = \Phi_5 = \Phi_6 = \Phi_7 = 0$, *i.e.,* no cointegration. Rejection of the null hypothesis requires the *F*-statistic to be higher than the upper-bound critical value.

The results of the test are summarized in Table 8 in Appendix 2. Although the Engle--Granger test indicates no cointegration between the underlying variables for mortgage debt as the dependent variable (Table 7 in Appendix 2), the bounds test confirms the presence of a cointegration relationship at a 1% confidence level. Therefore, we accept the results of the bounds test, indicating a long-term relationship. The estimates are summarized in Table 3.

Table 3: ARDL model estimations

Variable	Model 1		Model 2		Model 3	
Long-run relationship	**coefficients**	***t*-stats**	**coefficients**	***t*-stats**	**coefficients**	***t*-stats**
$\Delta \ln(HP)_{t-1}$	1.613	3.299***	1.238	2.904***	1.669	3.135***
$\Delta(HICP)_{t-1}$	−0.014	−0.887	−0.006	−0.391	−0.013	−0.845
$\Delta ln(rGDP)_{t-1}$	0.424	0.773	−0.245	−0.616	–	–
$\Delta ln(UNEM)_{t-1}$	0.161	1.427	0.128	1.220	–	–
$\Delta ln(rWAGES)_{t-1}$	−2.302	−2.155**	–	–	−3.027	−2.118**
$\Delta(RIR)_{t-1}$	0.009	0.317	−0.002	−0.079	0.013	0.435
C	0.026	2.646**	0.013	1.467	0.032	2.418**
Variable	**Model 1**		**Model 2**		**Model 3**	
Short-run relationship	**coefficients**	***t*-stats**	**coefficients**	***t*-stats**	**coefficients**	***t*-stats**
$\Delta \ln(LOANS)_{t-1}$	−0.788	−6.563***	−0.671	−5.714***	−0.832	−6.533***
$\Delta \ln(LOANS)_{t-2}$	−0.294	−2.519**	−0.205	−1.781*	−0.441	−2.735***
$\Delta \ln(LOANS)_{t-3}$	–	–	–	–	−0.207	−1.439
$\Delta \ln(LOANS)_{t-4}$	–	–	–	–	−0.181	−1.956*
$\Delta \ln(HP)_{t}$	−0.428	−1.743*	−0.368	−1.461	−0.452	−2.012*
$\Delta \ln(HP)_{t-1}$	−1.016	−3.608***	−1.150	−4.666***	−1.010	−3.081***
$\Delta \ln(HP)_{t-2}$	−0.596	−2.126**	–	–	−0.397	−1.320
$\Delta \ln(HP)_{t-3}$	0.264	1.296	–	–	–	–
$\Delta HICP_{t}$	0.003	0.723	0.005	1.232	−0.0001	−0.029
$\Delta HICP_{t-1}$	−0.006	−1.337	−0.011	−2.648**	−0.008	−1.758*
$\Delta HICP_{t-2}$	0.015	3.253***	0.017	3.869***	0.014	3.162***
$\Delta HICP_{t-3}$	–	–	−0.006	−1.398	–	–
$\Delta \ln(rGDP)_{t}$	0.179	0.794	−0.109	−0.622	–	–
$\Delta \ln(UNEM)_{t}$	0.068	1.452	0.057	1.201	–	–
ΔRIR_{t}	0.025	2.675**	0.027	2.763***	0.028	2.919***
$\Delta \ln(rWAGES)_{t}$	−0.459	−1.805*	–	–	−0.187	−0.902
$\Delta \ln(rWAGES)_{t-1}$	–	–	–	–	0.171	0.898
$\Delta \ln(rWAGES)_{t-2}$	–	–	–	–	0.377	2.001*
ECM_{t-1}	−0.421	−4.466***	−0.445	−4.706***	−0.391	−3.743***

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels respectively.

Source: Authors' computation based on EViews

The estimate of Model 1 shows the insignificance of certain parameters (both short-run and long-run), and that the distribution of the residuals is not normal at a 5% confidence level (based on the Jarque-Berra test). The adjusted *R*-squared of Model 1 reached a relatively high level (approximately 69%). However, the model does not take into account multicollinearity, which is obvious from the correlation matrix and was also checked via the variance inflation factor (VIF).

In order to eliminate the above-mentioned errors, we build another two models (Table 3). The second model does not use real wages as the exogenous variable. This variable was removed due to a high degree of linear dependency with the endogenous (dependent) variable. Nevertheless, Model 2 also suffers from some errors. The tests indicate heteroscedasticity and multicollinearity problems (based on VIF) and, in addition, the adjusted *R*-squared reached a lower level than in the first model.

Following these outcomes, we explore the third model by reducing the number of exogenous variables. Model 3 excludes real GDP and unemployment, but, unlike in Model 2, real wages are included as an exogenous variable. Figure 3 in Appendix 1 shows that real GDP and real wages go hand in hand in the observed period (they are highly correlated). Removing one of these two variables as an exogenous variable was, therefore, a step to reduce the multicollinearity of the model.

In the third model, we also do not take unemployment into account, due to the insignificance of the parameters of this variable in the first and second models. The residual tests produced by Model 3 confirmed their normal distribution, no serial correlation and no heteroscedasticity. From the perspective of multicollinearity, house prices are the only variable with a higher VIF value. On the other hand, our estimates confirmed that the elimination of this variable would lead to a worsening of the model (lower *R*-squared, insignificant parameters, multicollinearity caused by other variables, negative impact on residuals). Thus, we consider house prices to be an important proxy despite a certain level of multicollinearity. Finally, Model 3 displayed the highest value of adjusted *R*-squared and the lowest level of information criteria.

As mentioned above, all the models indicate a cointegration relationship between the underlying variables. The results of our analysis are presented in line with Model 3, which was constructed by eliminating the errors in Models 1 and 2. As the estimates show, there is a positive relationship between house prices and real mortgage debt in the long-term perspective, which is in line with our assumption in the first hypothesis. Thus, growth in house prices leads to a higher volume of granted loans, which implies a total mortgage debt increase. In addition, higher values of collateral may make the debt more affordable. Growing house prices are also expected to affect households in line with the wealth effect, which is also highlighted in the literature review. Our model also identified real wages

as a statistically significant variable determining the level of mortgage debt. However, we identified the opposite relationship (negative) to the one we expected in our hypothesis. The role of real wages can be explained in line with the two channels associated with the nature of this variable, *i.e.,* the nominal wage level and inflation. From the perspective of nominal wages, a positive contribution to the total of outstanding mortgage loans seems to be logical. Higher nominal wages lead to higher demand for loans, due to the greater ability to service debt, *ceteris paribus*. Inflation, on the other hand, affects households due to expectations of changes in monetary policy and a rise in interest rates and its real effects on debt (the positive contribution of inflation and real interest rates have been proved in the short run, see Table 3). The final relationship between loans and real wages depends on consumers' behaviour, *i.e.,* which channel proves to be stronger. Given the results of our analysis, a decrease in real wages should positively affect the level of mortgage debt via inflation. With regard to the statistical insignificance of the rest of the variables within the cointegration equation, we confirm house prices and real wages as the key variables determining the level of household mortgage debt in the long-run period.

From a short-run perspective, the estimated model shows that the level of mortgage debt is determined by its own lagged endogenous variables (*LOANS*), house prices, the inflation rate, real interest rates and real wages. The short-term contribution of lagged endogenous variables seems to be negative. This result may correspond to the fact that households with a certain level of debt cannot increase their indebtedness in the short run. The causality can be described as follows: The growth of household debt resulting from the drawing of mortgage loans determines the specific level of total household indebtedness. This debt usually serves to purchase houses, which indicates that the volume of these loans is relatively high and their maturity long-term. In this context, growing mortgage debt implies that there are limits to the taking out of further loans, and these limits are caused by the inability to service the increased debt arising from a new loan. On the other hand, Figure 1 shows relatively high year-on-year growth in total household debt in the Czech Republic. In that case, the above-mentioned causality will depend on the household sector's capacity to absorb newly issued debt.

Unlike in the case of the long-term relationship, we identified a positive contribution of real wages in the short-run perspective, which we mentioned above and which is in line with our expectation. The positive contribution of real wages seems to be driven by nominal wage growth in the short run compared to the stronger effect of inflation in the long run. An increase in nominal wages may encourage households to take out a loan due to their increasing ability to service that debt. This behaviour can be associated with an optimistic expectation of their future income and the resulting growth in their resources in the short term. By contrast, the long-run expectation seems, in line with

our results, to be more pessimistic due to changes in inflation and a potential increase in the costs of credit.

With regard to real interest rates, we confirmed a relatively weak positive relationship. This finding, however, does not correspond to our assumption. On the other hand, the positive relationship can be explained by households' expectation of a rise in interest rates in the future, which leads them to prefer to take out loans in the short term. In line with this, we can identify a front-loading effect, which is visible in the dynamic of newly issued mortgage loans. Higher demand leads credit institutions to increase interest rate margins to reflect the market situation. Moreover, a positive relationship can also be caused by the lower sensitivity of households to changes in interest rates, especially when the growth is relatively slow and the nominal wage growth is, by comparison, higher.

We also confirmed the weak positive contribution of inflation in the short run. As mentioned above, the rise in the inflation rate could be caused by the growth in wages, *i.e.,* household income, which makes mortgage loans more accessible. Moreover, an increasing inflation rate implies a restrictive monetary policy. In line with this, rational households tend to increase their indebtedness due to a reduction in the real value of debt.

Despite the positive contribution of house prices over the long term, we identified negative relationships between mortgage debt and the level of house prices in the short term. The rise in house prices may reduce the affordability of mortgage loans in the short term, especially when the rise is greater than income growth. In addition, higher house prices do not only cause growth in potential loan principals, but also lead to higher household saving requirements (depending on the current LTV limit applied). It is, however, very difficult (or impossible) to increase the volume of savings for households in the short run. This constraint will determine the negative contribution of house prices over the short term.

One remarkable output is the insignificance of the unemployment rate in the first and second models. There are several possible reasons for this outcome. The first is the endogenous variable. Our model is aimed at explaining the development of mortgage loans granted to households for housing purposes. Increasing unemployment may not lead to an increase in mortgage loans because of a preference for smoothing consumption (*i.e.,* consumers are more willing to take out short-term loans, which can be used not only for consumption but also for servicing their long-term debt). The growth in unemployment may also not lead to a decrease in the mortgage loan stock due to the unemployment structure. The Czech Statistical Office data confirm that the highest number of unemployed Czech citizens is reported in groups aged between 35 and 54 and with lower education; see, for example, also Petrušová *et al.* (2018). We may assume that citizens in this age cohort do not take out mortgage loans, because such loans have a shorter term to maturity, which leads to higher debt service. Moreover, borrowers with lower education are assumed

to have relatively lower incomes and savings compared to people with a higher level of education. The second reason is that the level of unemployment has fallen to low levels in the Czech Republic in recent years. According to Eurostat statistics, the Czech Republic reported a 2.8% unemployment rate at the end of 2021, which is the lowest within the EU. These facts show that unemployment plays no, or only a very limited, role in determining the level of household mortgage debt in the Czech Republic. However, unemployment may play a greater role in other economies, depending on the country-specific situation.

4. Results and Discussion

Our analysis of the variables determining the level of Czech households' mortgage debt leads to the following results. Firstly, we ran a cross-correlation analysis. The correlation coefficients show a positive influence of real GDP, house prices and real wages. By contrast, a negative relationship is identified in the case of long-term real interest rates, the unemployment rate and the level of inflation. The results of the correlation analysis prove a relatively high degree of linear dependency (positive or negative). The reverse relationship has been identified in the case of inflation. Unlike other researchers, Morais *et al.* (2014) present a positive influence of inflation on household debt. This result may be caused by some weaknesses in the correlation analysis and the potentially different behaviour of the household sector when making a decision on whether to increase its own indebtedness, as well as country--specific conditions. We do not, therefore, reject the stated hypotheses.

Secondly, we explored the ARDL model in order to separate the long-run and short-run relationships of the underlying variables. We identified one cointegration relationship determining the long-run equilibrium. In the long run, the level of household mortgage debt seems to be determined by house prices (positive influence). Our findings confirm the results of the above-mentioned research, such as Stockhammer and Wildauer (2018), Basten and Koch (2016), Philbrick and Gustafsson (2010) or Khan *et al.* (2016). On the other hand, we identified the negative influence of real wages, which is not in line with our expectation. However, we conclude that the negative contribution of real wages in the long term is associated with the role of inflation connected with the growth in nominal wages, pessimistic expectations of restrictive monetary policy and the real effect of inflation on debt. Our finding is supported by short-run impact estimates of inflation. With respect to other research, Davenport (2003) documents a negative impact of income per capita on the availability of owner-occupied housing.

From the short-term perspective, the estimated model shows that the level of mortgage debt is determined by its own lagged endogenous variables, house prices, real wages, real interest rates and the level of inflation. In the case of real wages, the results confirm the assumed positive relationship, which is driven by nominal wage growth. This result is

in line with Jacobsen *et al.* (2014). On the other hand, we identified a negative influence of real wages, which is not in line with our expectation. However, we conclude that the negative contribution of real wages in the long term is associated with the role of inflation connected with growth in nominal wages, pessimistic expectations of restrictive monetary policy and the real effect of inflation on debt. Our finding is supported by short-run impact estimates of inflation. With respect to other research, Davenport (2003) documents a negative impact of income per capita on the availability of owner-occupied housing.

Real interest rates and the inflation rate seem to contribute positively in the short term, whereas house prices tend to affect mortgage debt negatively in the short-term perspective. These findings are markedly different from the correlation analysis and our hypothesis. In this context, we reject the first hypothesis in particular. Our model signals the opposite relationship between the level of debt and interest rates. Our analysis also shows that unemployment plays a very limited role or no role at all on the Czech mortgage market, which is due to the low level of unemployed households and the country-specific structure of the macroeconomic variables. This outcome leads us to reject the second hypothesis.

Our analysis yielded several results that are not in line with our assumptions. It should be highlighted that the determinants may differ across countries depending on the country-specific development of the mortgage market and household preferences associated with housing needs (see, for example, Lombardi *et al.* (2017)). This analysis also provides a basis for further research, which could be built on other exogenous variables that would scale up the model. Testing more exogenous variables could bring valuable results for the variables that are responsible for mortgage debt development. We assume that the above-mentioned macroprudential regulation may play a significant role in determining the level of mortgage debt. Moreover, conducting an impulse response analysis would enable evaluation of the impact of this regulation. Within this context, our objective therefore is to scale up our model in order to improve the outcomes of our research.

5. Conclusion

This paper focused on the determinants of Czech household mortgage debt. The objective of our analysis was to examine the role of real GDP, house prices, real interest rates, inflation, unemployment and real wages and their impact on household mortgage debt. Our study was based on correlation analysis and cointegration analysis. The contribution is two-fold:

Firstly, we tested two hypotheses about the expected relationship between observed variables within a cross-correlation analysis. The results confirmed negative dependency on interest rates, the unemployment rate and also inflation. By contrast, real GDP, real wages and house prices contribute positively to mortgage debt growth. The outcomes are in line with our hypotheses, excluding the expected relationship between debt and inflation.

Secondly, we examined the long-term relationship between the variables within the co-integration analysis based on the ARDL model, and the results were further exploited to construct an EC model in order to distinguish the short-term and long-term behaviour of mortgage debt. From the long-term perspective, the mortgage debt is positively affected by house prices and real wages. The short-run deviation from the equilibrium state is caused by its own lagged endogenous variables, real wages, the level of house prices, interest rates and inflation. Our estimates differ from our assumption in the tested hypotheses.

Appendix 1: Information about the dataset

Table 4: Dataset

Variable		Source	Data frequency
Outstanding mortgage loans (CZK million)	*LOANS*	Czech National Bank	monthly
Harmonised index of consumer prices	*HICP*	Czech Statistical Office	monthly
10Y government bond yields	*RIR*	Czech National Bank	monthly
Average nominal gross wage	*rWAGES*	Czech Statistical Office	quarterly
House prices	*HP*	Czech Statistical Office	quarterly
Nominal GDP	*rGDP*	Czech Statistical Office	quarterly
Unemployment rate	*UNEM*	Czech Statistical Office	monthly
GDP deflator	–	Czech Statistical Office	quarterly

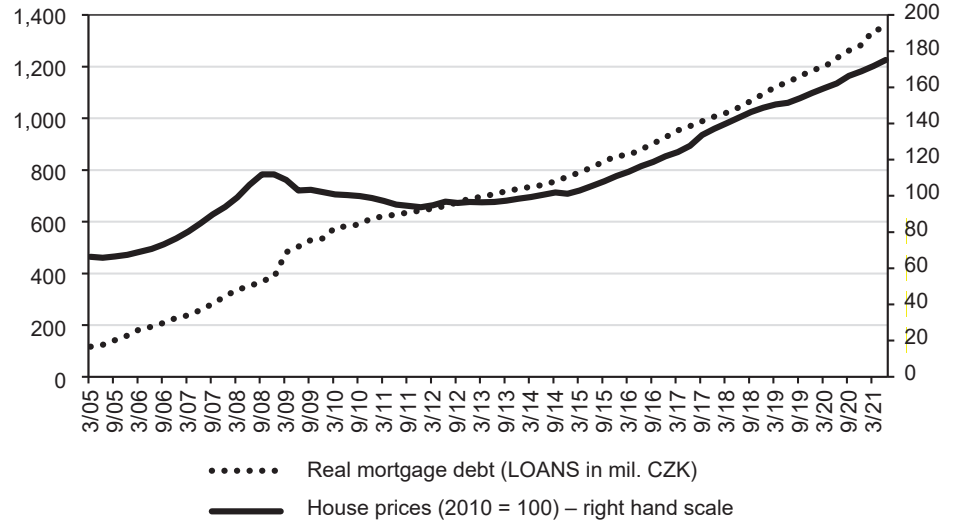
Source: Czech National Bank (2022), Czech Statistical Office (2022)

Table 5: Time series statistics

Variable	*HP*	*LOANS*	*rGDP*	*rWages*	*RIR*	*UNEM*	*HICP*
Mean	110.95	706,703.2	1,096,536	25,819.51	2.55	5.26	2.10
Median	102.00	701,415.7	1,044,324	24,705.43	2.22	5.77	2.00
Maximum	175.10	1,348,681.0	1,471,870	37,183.14	5.13	8.13	7.57
Minimum	65.80	116,615.8	744,899.4	16,808.93	0.30	1.93	0.13
Std. Dev.	28.58	341,049.3	185,556.2	4,998.31	1.46	1.99	1.56
Observations	66	66	66	66	66	66	66

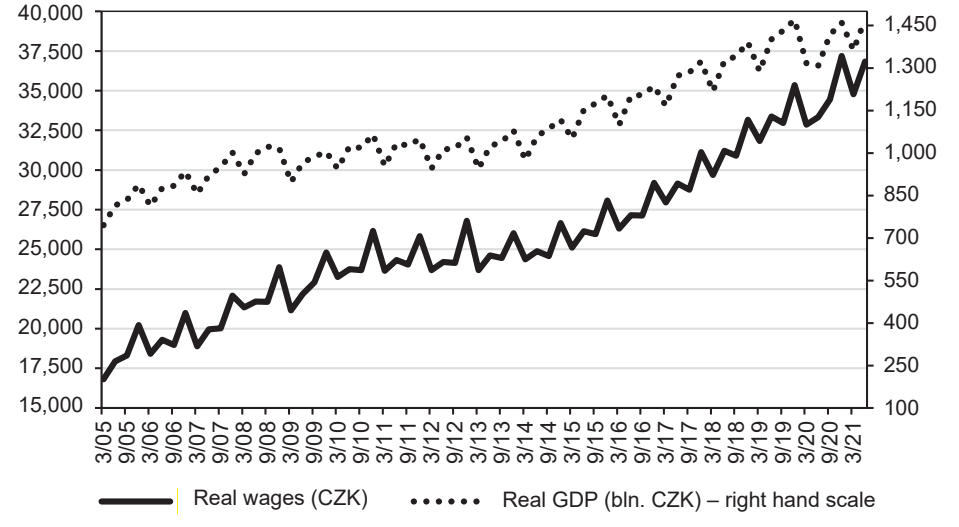
Source: Authors' computation based on EViews

Figure 2: Development of real mortgage debt and house prices



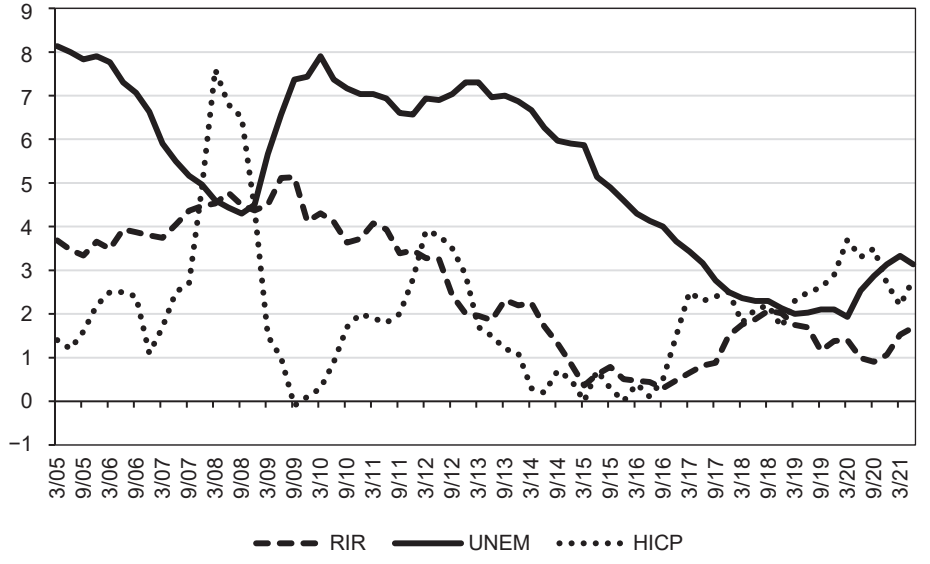
Source: Czech Statistical Office (2022), Czech National Bank, authors' computation

Figure 3: Development of real GDP and real wages



Source: Czech Statistical Office (2022), authors' computation

Figure 4: Development of real interest rates, unemployment and consumer prices



Source: Czech National Bank (2022), Czech Statistical Office (2022), authors' computation

Appendix 2: Statistics regarding estimated ARDL models

Table 6: Descriptive statistics of estimated ARDL models

	Model 1	Model 2	Model 3
R^2	0.784	0.744	0.798
Adj. R^2	0.692	0.658	0.702
Akaike Information Criteria	−4.901	−4.827	−4.939
DW stat	2.011	2.078	2.003
Jarque-Berra	8.400 (0.015)	3.880 (0.143)	3.030 (0.220)
Breusch-Godfrey (LM test)	1.020 (0.371)	0.570 (0.569)	1.510 (0.235)
ARCH test	0.382 (0.539)	7.925 (0.007)	0.020 (0.875)

Note: The table includes the *t*-statistics of the Jarque-Berra test (normality of residuals), Breusch-Godfrey test (serial correlation of residuals) and ARCH test (heteroscedasticity). The *p*-values of the tests are in brackets.

Source: Authors' computation based on EViews

Table 7: Engle-Granger cointegration test

Dependent variable	Tau-stat	Prob.	*Z*-stat	Prob.
ln*LOANS*	–1.723	0.996	–8.598	0.992
ln*HP*	–2.662	0.933	–12.521	0.951
HICP	–2.937	0.871	–35.105	0.098
ln*rGDP*	–4.379	0.254	–30.624	0.221
ln*UNEM*	–1.996	0.991	–11.557	0.966
ln*WAGES*	–3.363	0.717	–18.424	0.768
RIR	–3.276	0.753	–17.323	0.814

Source: Authors' computation based on EViews

Table 8: Bounds test of cointegration

	Model 1	Model 2	Model 3
***F*-statistic**	**4.74**	**4.52**	**5.76**
I(1) Bound critical value (10% significance)	3.23	3.35	3.52
I(1) Bound critical value (5% significance)	3.61	3.79	4.10
I(1) Bound critical value (2.5% significance)	3.99	**4.18**	4.49
I(1) Bound critical value (1% significance)	**4.43**	4.68	**5.60**

Source: Authors' computation based on EViews

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